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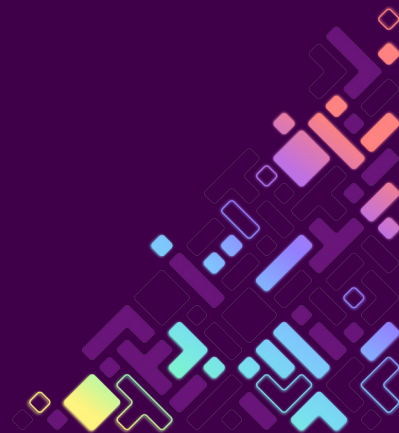
Embedded Linux in EOD Robots - Lessons Learned

Marcin Bis, PIAP



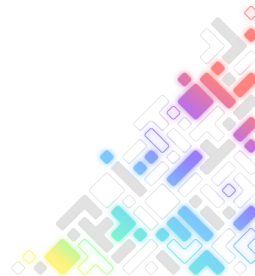
#osummit

marcin.bis@piap.lukasiewicz.gov.pl



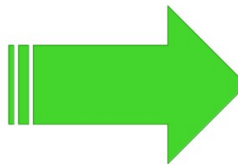
What is an **EOD** robot?

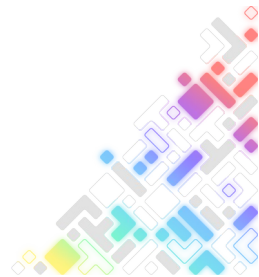
- Explosive Ordinance Disposal (EOD)
- An Integrated Mobile System for Counterterrorism and Rescue Operations

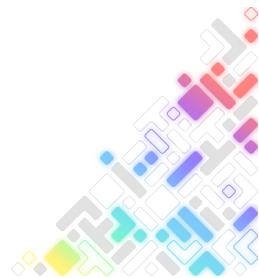


The main goal is to

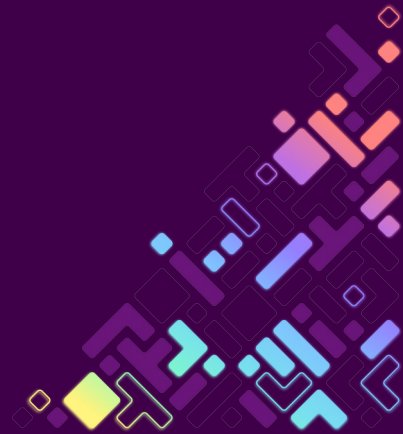
push humans away from threads







The Institute





Industrial Research Institute for Automation and Measurements, PIAP (est. 1965)

<https://piap.lukasiewicz.gov.pl/en/>

- the first industrial robots producer in Poland (under ASEA/ABB license, 1976)
- the first mobile robots manufacturer in Poland (INSPECTOR, 1999)

Part of Łukasiewicz Research Network

<https://lukasiewicz.gov.pl/en/>

- Robotics for Security, Science and Industry, Integrated Mobile System for Counterterrorism and Rescue Operations





About Me – Marcin Bis

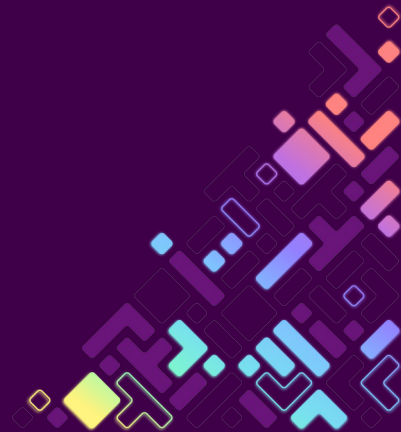


- I build mobile robots, they are like supercars!
- I am responsible for making thing done.
 - I develop custom tailored, Yocto Project based, Embedded Linux BSP, including device drivers, and userspace applications,
 - a base building block of all digital UGV systems offered by PIAP, sold worldwide,
 - I try to unleash the full performance out of the hardware (and squeeze bugs).

The views and opinions expressed in this presentation are mine and do not necessarily reflect the views or positions of any entity I represent.



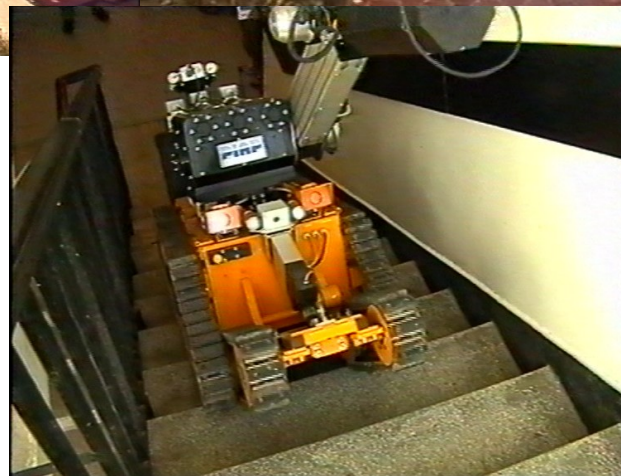
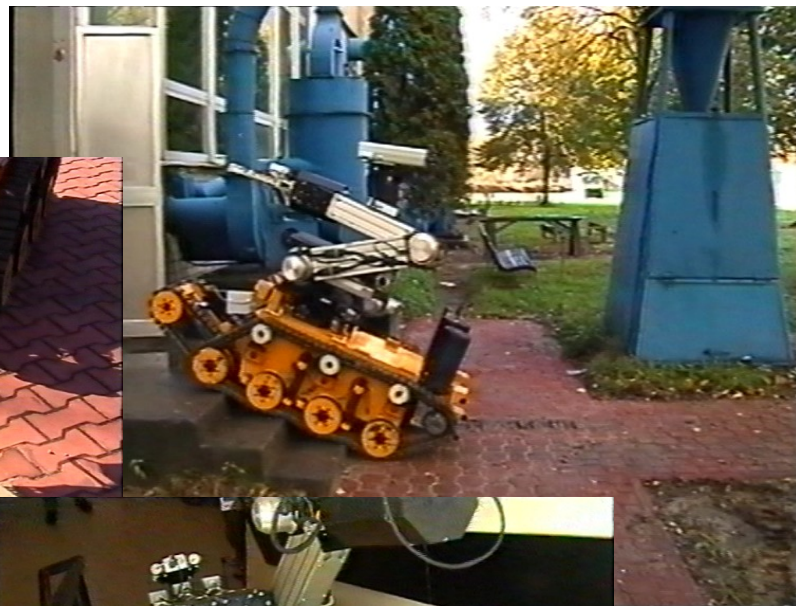
History

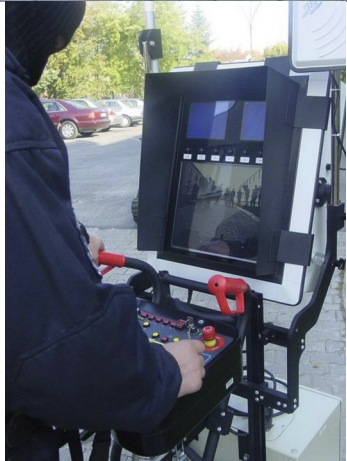


1999 INSPECTOR

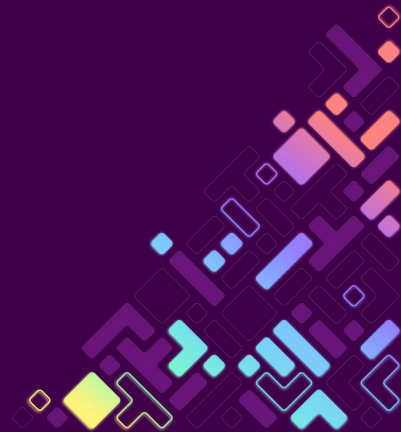



1999 INSPECTOR

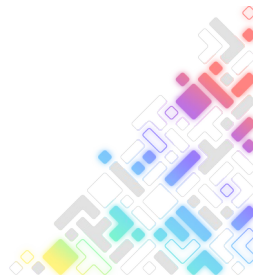




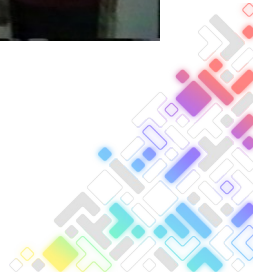
How to build a robot?



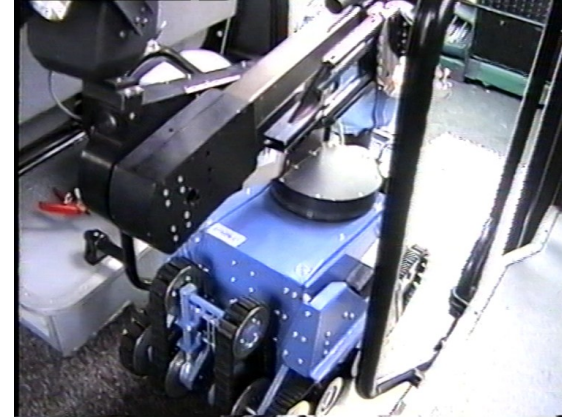
- Idea: start with a  box and a plane (eg. Boeing 737).
- ... and a train,
- ... and a bus.



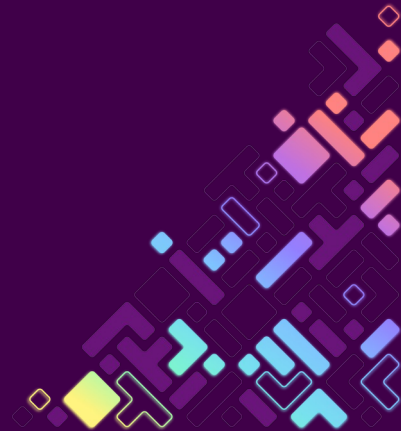
How to build a robot – take a box to a plane.



... – a year after



Go digital



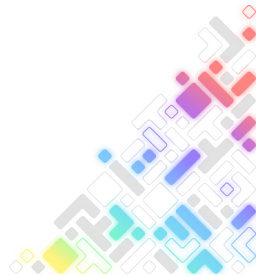
Software Engineering problems

- This is not a programming problem, nor a mechanical problem.
- It is a **robotics** problem.
- Linux and programming is only a single brick in the wall.
- Stays as a reminder that there is no such thing as a simple problem.



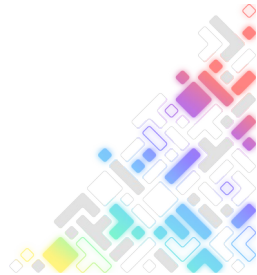
Mechanics and electronics

- Needs to be resistant and resilient
- Has sufficient power (speed, torque, lift)
- Yet, do not drain battery too fast.

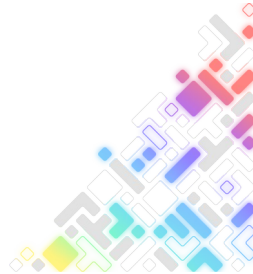


Put a software on it.

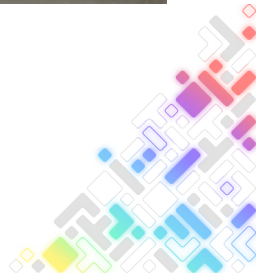
- Motors
- Video
- Radio communication
- Low-Latency, safety critical, user experience ...



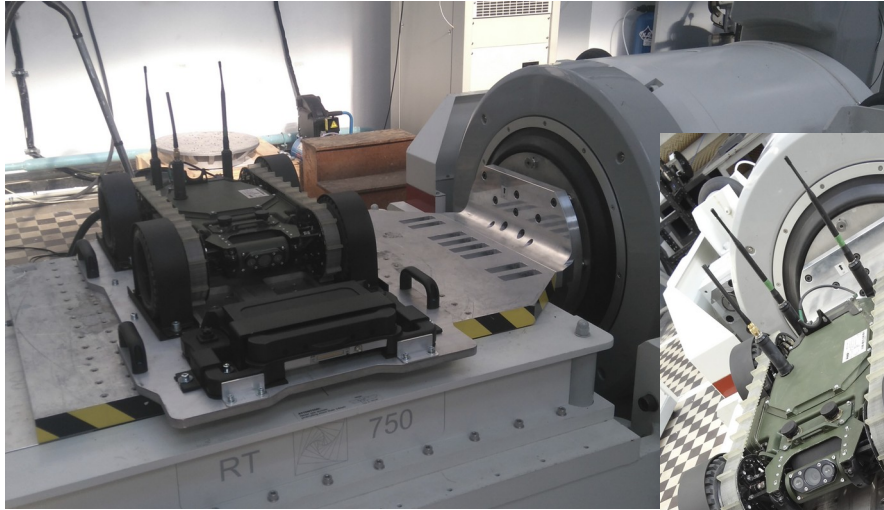
How to harras a robot – freeze it.



How to harras a robot – drown it.



How to harras a robot – shake it and heat it.



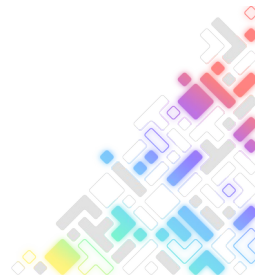
How to harras a robot – finally exercise it!



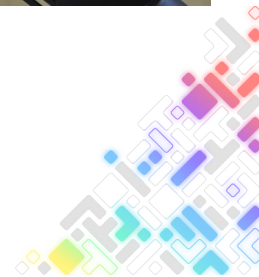


EOD vs. Industrial Robots

- Agile rather than fast,
- Versatile,
- Usually teleoperated or with a human in the loop,
- Yet, sometimes quick and precise:

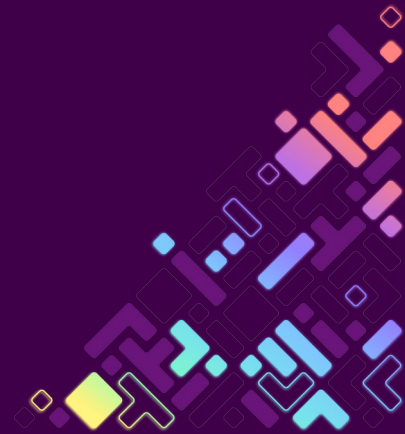


Agility



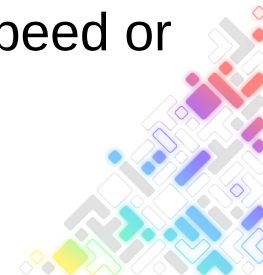


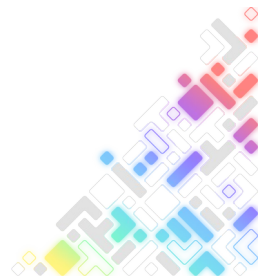
Software Engineering



Safety-critical

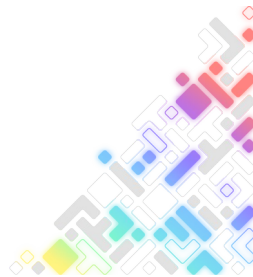
- The core components of the UGV have to be safety-critical.
This is achieved by designing the hardware such way (mechanical parts and electronics).
- The electronic component can burn in a way that the circuit stay on.
Your code might not work because of it.
- There is an "Emergency Stop" button.
If it is the circuit breaker, will it work when robot is moving at speed or would it fry the motor controller?





Real-Time Linux

- Use PREEMPT-RT
- Off load real time tasks to microcontroller.



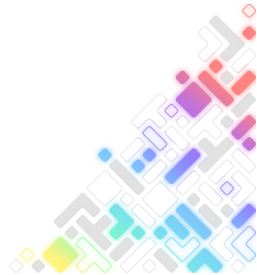
BSP

- The goal: provide a sustainable build system for a programmer.
- Make it easy to on-board new programmers (incl. students, internship etc.)
- Maintain the system for multiple years (at least 10).



BSP

- Linux distribution (Debian/Ubuntu based)
- Buildroot
- Yocto Project



Yocto Project

- Finally settled to it in 2019
- Different Architectures (ARM, ARM64, x86-64).
- The core system for robots, consoles, repeaters, etc.
- Need to integrate many meta-layers (some exotic ones too).





widok 1

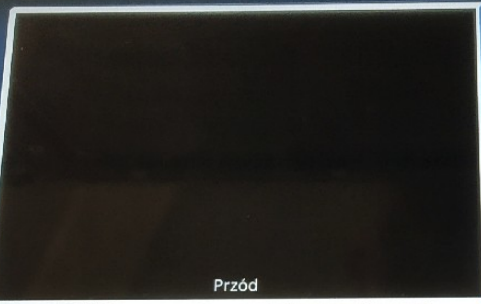
widok 2

widok 3

widok 4



tryb szybki



Przód



Infrared

mapowanie 1

mapowanie 2

mapowanie 3

mapowanie 4



Główna



Chwytak



wybrano 2



single



model 3D



kamera



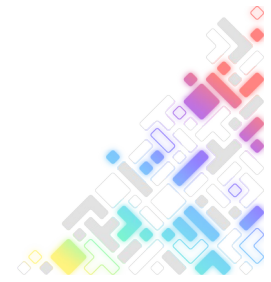
pełny ekran



Sensors



stop



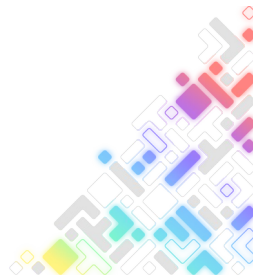
Yocto Project

- Keep it modular.
- Maintain as little variants as possible.
- Ideally – stick everything to the latest LTS version.
- Off-line builds (keep everything in-house)



Yocto Project

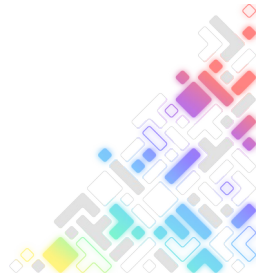
- Update periodically.
- `INHERIT += "cve-check"`
- Keep track of upstream.



CI/CD

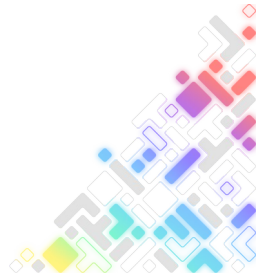
It takes TB to re-build everything.

- Cache sometimes corrupts.
- Try to distinguish BSP builds (rare) from Application builds (very frequent).
- GitLab, Buildbot

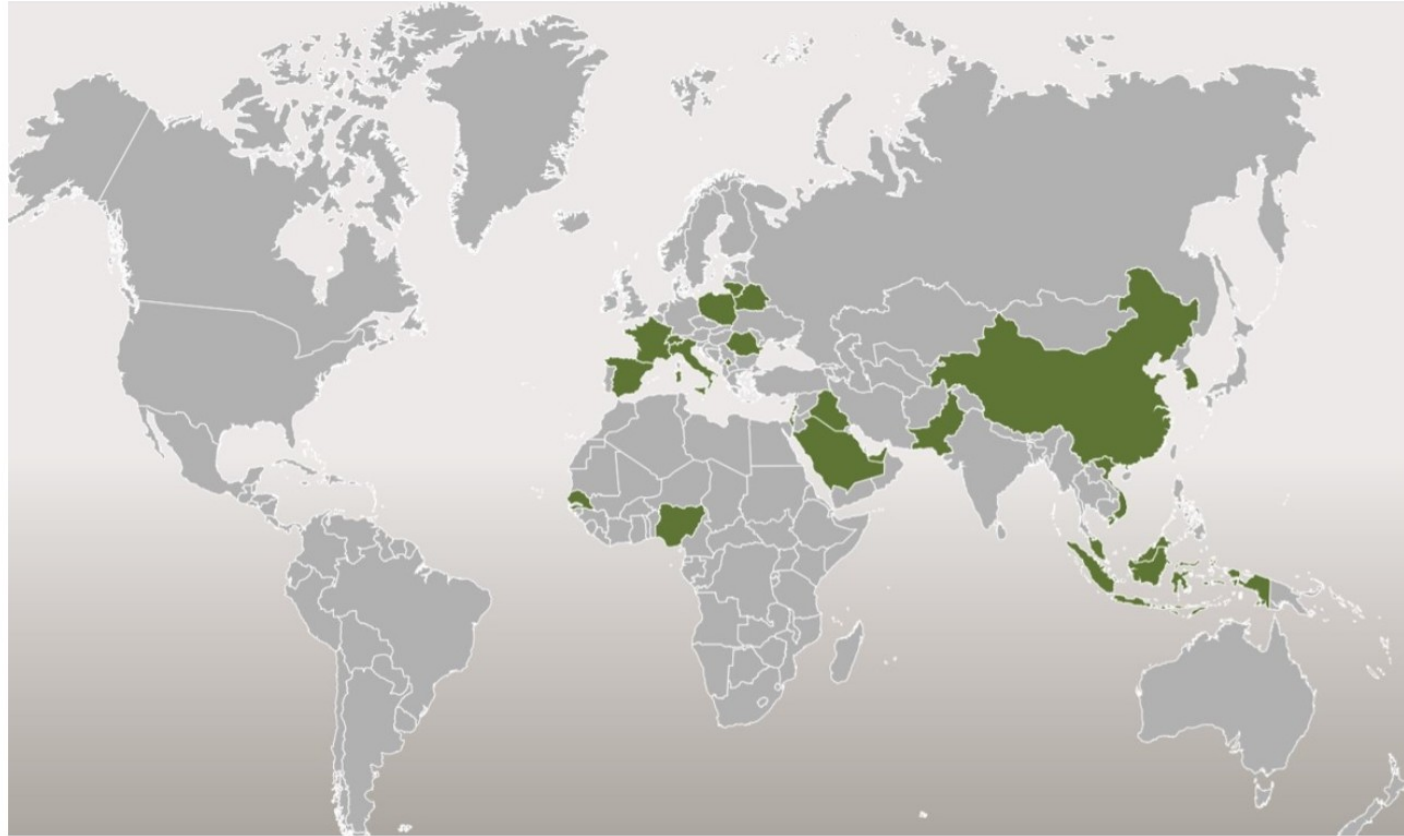


Software Update

- Keep it modular
 - Local system updates
 - Maintenance of device worldwide



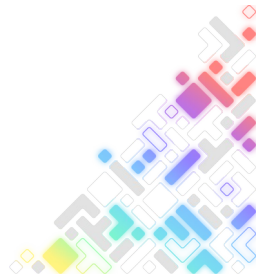
Łukasiewicz - PIAP
is in top 5 major
EOD mobile robot
producers



Our major markets: *Saudi Arabia, United Arab Emirates, South Korea, Nigeria, Vietnam, Indonesia, Pakistan, Senegal, France, Romania*

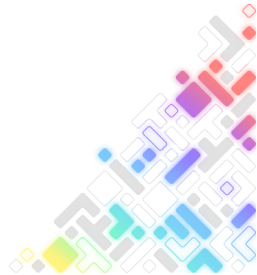
Software Update

- SWUpdate
 - Rauc <https://rauc.io/>
 - Mender.io <https://mender.io/>
 - Update Linux Image, bootloader and a bunch of external microcontrollers.
- Server, e.g. <https://eclipse.dev/hawkbite/>
 - Device not always on-line
 - Cloud cost is a big factor.

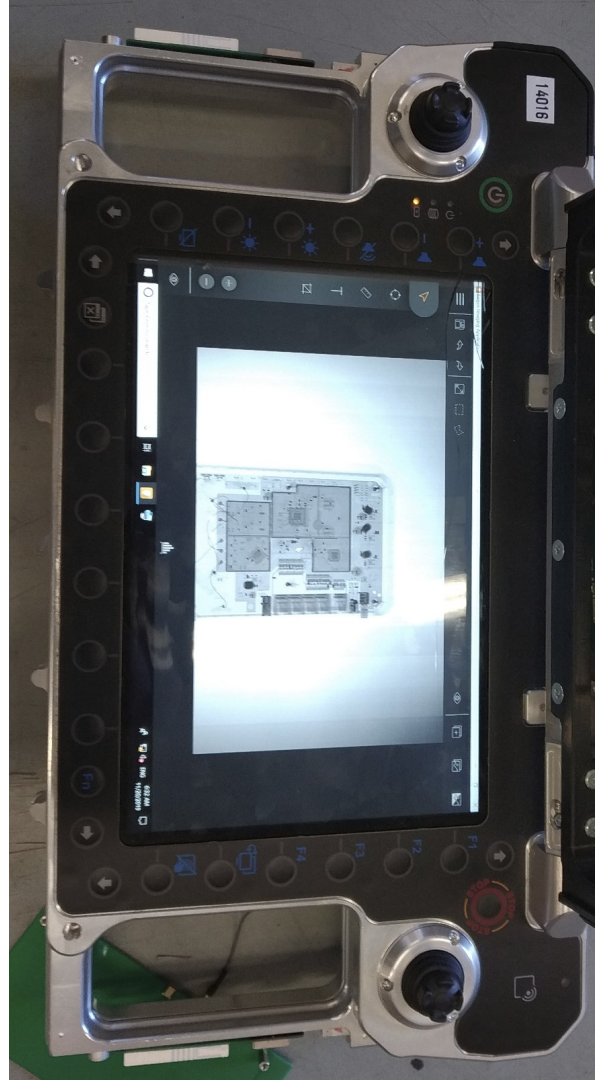
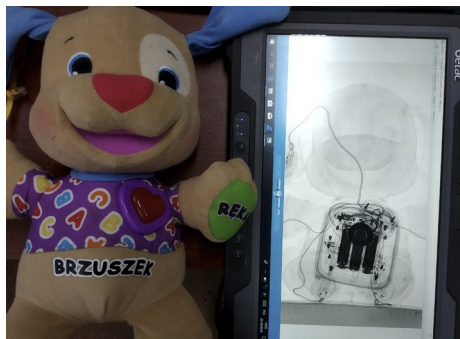


Integration of an „exotic” software

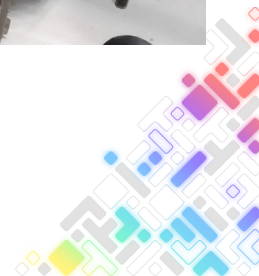
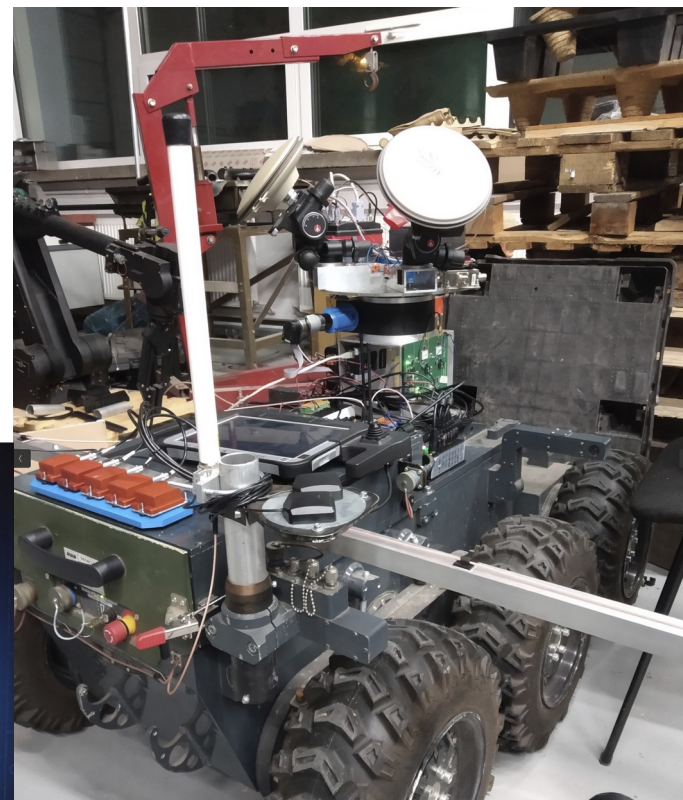
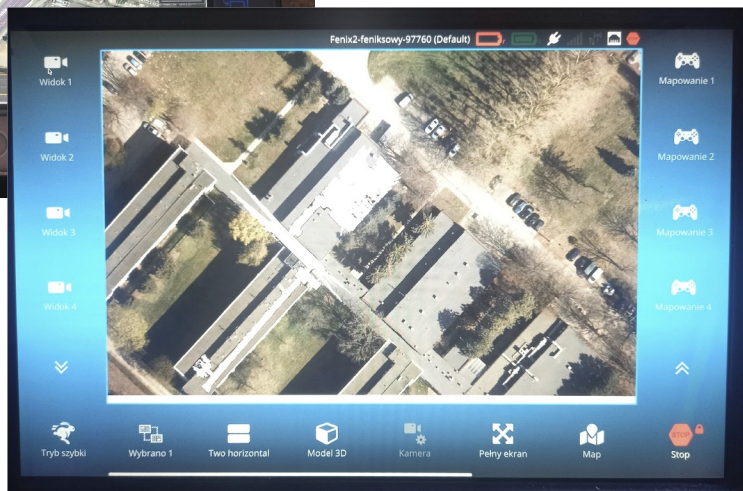
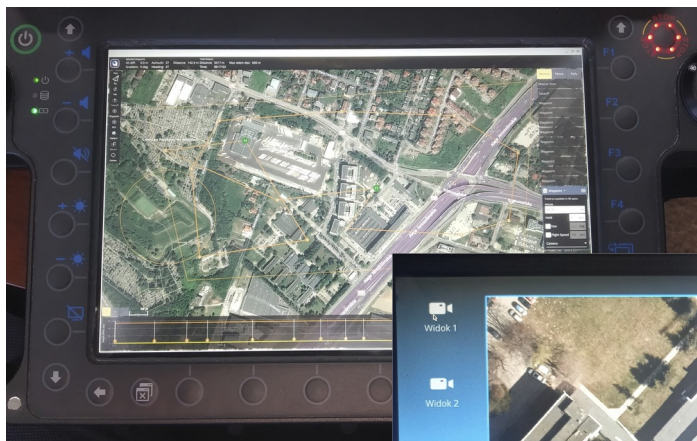
- X-RAY – Only runs in Windows
- Maps – Offline is a must-have!
- Research projects
 - Many one-time R&D projects
 - ROS integration: <https://www.ros.org/>



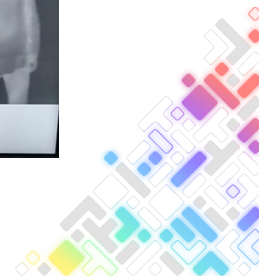
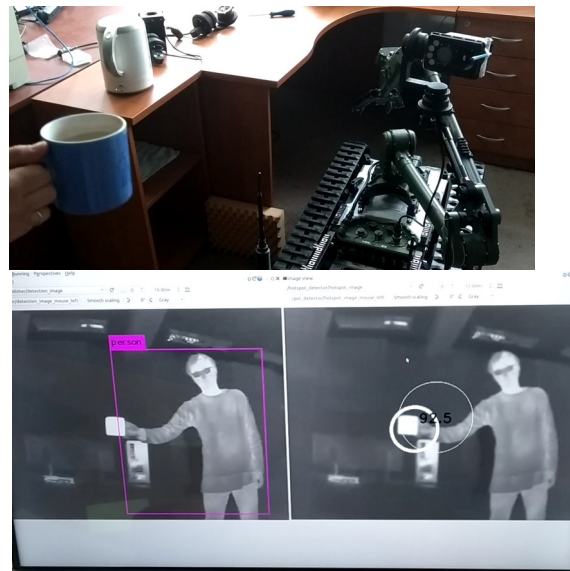
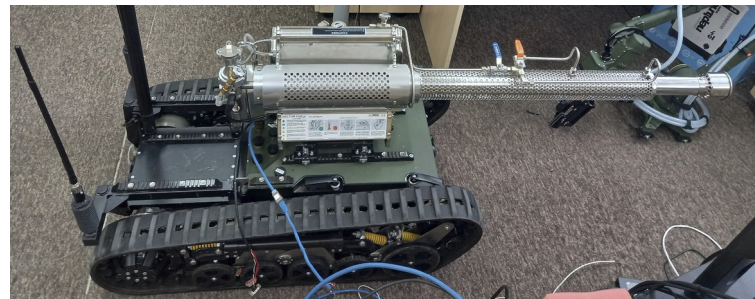
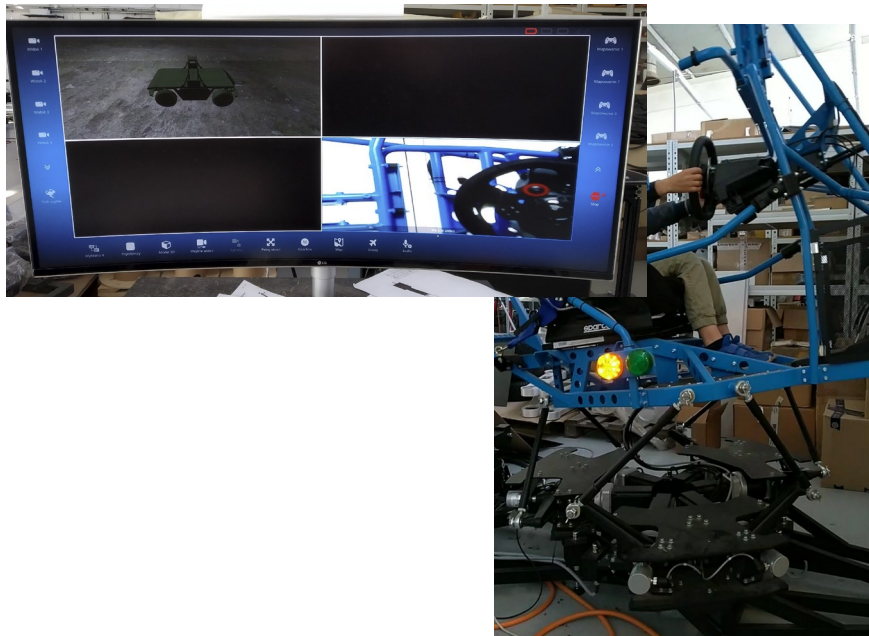
X-RAY



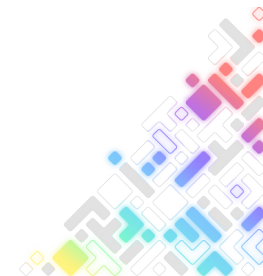
Maps and GNSS



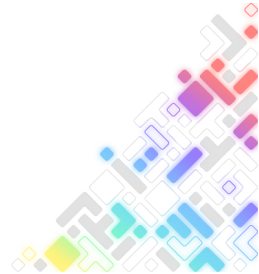
One-time & research projects.



PIAP HUNTeR – a 3.5t platform



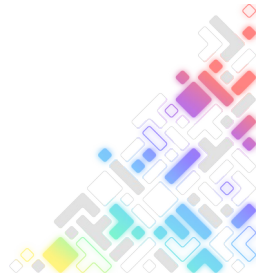
ATENA - a self driving off-road 4x4



Integration of an „exotic” software

- Windows – KVM/QEMU virtualization
- Containers:
 - Systemd-container
 - DockerCE -

<https://git.yoctoproject.org/meta-virtualization>



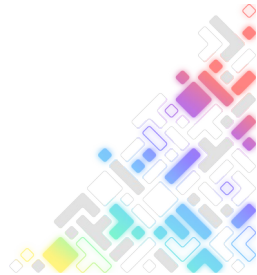




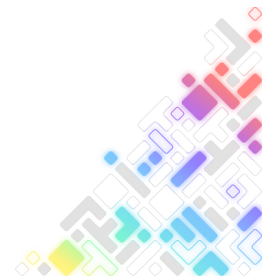
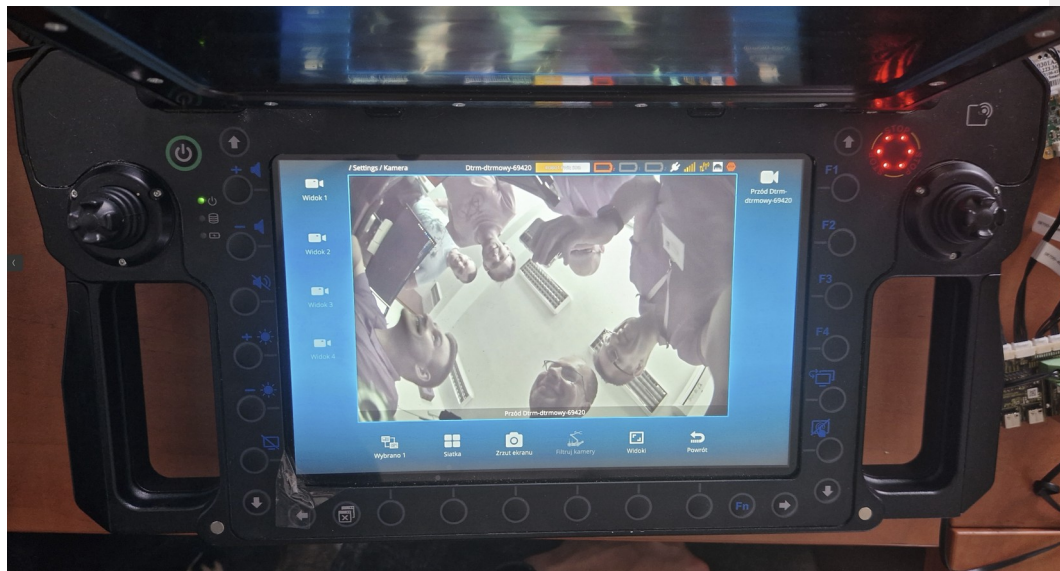
It takes:

- a bunch of smart people
- and a great amount of institutional knowledge to build a succesful UGV system.

We try hard not to walk in place...



What a newborn robot see?



Thank You for your attention!

marcin.bis@piap.lukasiewicz.gov.pl



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www.antiterrorism.eu

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